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3 April 1970

Materiel Test Procedure 3-3-503
U. S. Army Armor and Engineer Board

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U. S. ARMY TEST AND EVALUATION COMMAND
COMMON SERVICE TEST PROCEDURE

BORESIGHT AND ZERO

1. OBJECTIVE

The objective of this Materiel Test Procedure (MTP) is to outline procedures for use in boresighting and zeroing weapons and checking boresight retention.

2. BACKGROUND

Weapons vary in their performance due to inherent differences, such as wear, jump, and tube droop. The range scales used in fire control equipments are based on standard range table angles of elevation and make no allowance for the varying characteristics of individual weapons. To compensate for the variation in performance, sights must be adjusted. This adjustment must be accomplished periodically as the movement of the weapon system and firing may cause sights to move out of adjustment. Accurate sight adjustment is fundamental in gunnery; it is impossible to fire accurately without it.

Boresighting provides the basis for all sight adjustment. It is performed to establish a definite relationship between the axes of the weapon and the direct fire sight(s), and when applicable, the coaxially mounted searchlight. Boresighting is accomplished to facilitate zeroing.

Zeroing is the firing of the weapon to adjust the sights so that the point of aim and the point of strike of the projectile coincide as nearly as possible at a given range thereby increasing the accuracy of fire at all direct fire ranges.

Boresight retention is the ability of a sighting system to remain in angular alignment with gun bore. Loss of alignment is usually caused by vibration and shock induced by firing or moving the weapon system, and sometimes by sharp changes in temperature. Boresight loss is not restricted to fire control systems alone, it can be caused by tube droop or the weapon assuming new angular positions within its mounting.

3. REQUIRED EQUIPMENT

a. Binoculars
b. Boresight Equipment, as required for specific test item(s),
such as:

- 1) Muzzle crosshair or muzzle boresight, if available
 - 2) Breech boresight, if available
 - 3) Spotting scopes
 - 4) Pullover gauge
- c. Appropriate Targets, as required for sight adjustment, boresight,
STATEMENT OF TEST

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zeroing, and boresight retention checks, such as:

- 1) Gridded target
- 2) Boresight and zero target
- d. Range Facilities as required, including appropriate regulations.
- e. Ammunition, as required for warm-up, and zeroing main gun, and machine guns.
- f. Qualified Gunner's M1A1 Quadrant, as required for checking elevation during alignment and retention checks.
- g. Meteorological facilities for weather data, in particular:
 - 1) Anemometer
 - 2) Wet and dry bulb thermometer

4. REFERENCES

- A. USATECOM Regulation 385-6, Verification of Safety of Materiel During Testing.
- B. USAMC Regulation 385-12, Safety Verification of Army Materiel.
- C. MTP 3-3-500, Preoperational Inspection and Physical Characteristics.

5. SCOPE

5.1 SUMMARY

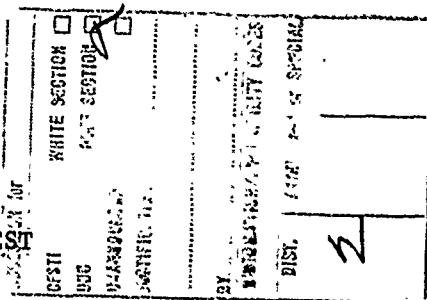
This MTP outlines procedures for:

- a. Preparation for Test - A determination of the condition of the test item weapon system and necessary repairs and adjustments and an indication of personnel requirements.
- b. Adjustment Limits for Boresighting - A determination of the limits of adjustment of associated sights provided for boresighting the main gun, searchlight, and the coaxial and cupola mounted machine guns.
- c. Boresighting - A determination of the boresighting capability, as determined by boresight adjustment limits of movement remaining after boresighting the main gun, searchlight, and coaxial and cupola mounted machine guns.
- d. Zeroing - A determination of the zeroing capabilities of the test items boresighted main gun and coaxial and cupola mounted machine guns.
- e. Boresight Retention - A determination of the deviation in sight alignment and backlash in the test item elevating and traversing systems, if any, which may be caused by firing on test vehicle operation.

5.2 LIMITATIONS

This MTP is primarily for use in boresighting and zeroing the main armament and coaxially mounted weapons in combat vehicles. However, with some modification, the principles, insofar as they are applicable, can be used for other direct fire weapon systems.

6. PROCEDURES



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6.1 PREPARATION FOR TEST

6.1.1 Safety

The test officer shall ensure that a Safety Release in accordance with reference 4A has been received from HQ USATECOM and is understood.

NOTE: A Safety Release includes information pertaining to operational limitations and specific hazards peculiar to the test item.

6.1.2 Personnel

- a. Selected well-trained personnel should be used for these tests unless otherwise directed.

NOTE: There may be occasions when personnel with various levels of training are used for the purpose of establishing training doctrine.

- b. All test personnel should be trained on the specific test item in accordance with pertinent technical manuals, and the following should be recorded for each:

- 1) Name, and rank or grade
 - 2) Military Occupational Specialty (MOS)
 - 3) Experience in MOS

6.1.3 Pretest Inspection

- a. Inspect the weapons system including available sights and controls, in accordance with pertinent technical manuals and MTP 3-3-500.
 - b. Repair and/or adjust the weapon system as needed to place the materiel in the best possible operating condition.
 - c. Record the following:
 - 1) Nomenclature and serial number of each weapon/system to be tested, and of the vehicle in which it is installed.
 - 2) Adjustments and/or repairs made to the weapon system.

6.2 TEST CONDUCT

NOTE: The guidance in this paragraph is of a general nature and should be used in conjunction with pertinent technical manuals or other appropriate documents.

6.2.1 Adjustment Limits for Boresighting

NOTE: It is necessary to measure these limits before and after boresighting to ensure that adequate adjustment is provided in the system.

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6.2.1.1 Prior to Boresighting

a. Position the vehicle under test and related sighting devices on a suitable range, as follows:

- 1) As required for sight adjustment using the built-in measuring devices of the sights, if provided, or
- 2) At the exact distance from a gridded target corresponding to the established mil values of the basic grid.

NOTE: The gridded target should permit measurements corresponding to angular accuracy of 0.01 mil as shown in sample target of Appendix A.

b. For built-in measuring devices determine and record the maximum vertical and horizontal limits of movement provided in the various adjustments.

c. When using a gridded target orient each sighting device to the center of the grid and determine and record the maximum vertical and horizontal limits of movement provided in the various adjustments.

NOTE: In some cases such as the coaxial machine gun and the searchlight for tanks, the limits of movement are measured at the mounts.

6.2.1.2 Subsequent to Boresighting

a. After boresighting (paragraph 6.2.2 below), measure and record the remaining limits of movement to the left and to the right, and above and below, the boresight setting, for each item.

b. Compare the figures of step a with those obtained in paragraph 6.2.1.1 above, to determine whether there is adequate reserve movement to cover the variances in tolerances to be expected from one installation to another.

6.2.2 Boresighting

Boresight the main gun, coaxial and cupola-mounted machine guns, and the coaxially mounted searchlight in accordance with the pertinent technical manual(s) and other applicable documents by performing the following:

a. Position the weapon system as level as possible to eliminate or reduce cant error, charge the manual accumulator on those weapon systems so equipped.

b. Record the following for each subparagraph below:

- 1) Identity of each technical manual or other document used for boresighting instructions.
- 2) The range at which each item was boresighted.
- 3) Type of tools, equipment, and targets used.
- 4) Any difficulties encountered during boresighting.

6.2.2.1 Main Gun

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- a. Position a target (such as the one shown in Appendix B) with a clearly defined right angle at the specified boresighting range.
- b. Boresight the particular weapon system, as prescribed using the appropriate technical manual or other technical document.

NOTE: There are many different weapons used as the main gun on the various types of combat vehicles. The equipment required and the procedures used in boresighting these weapons vary considerably as does the nomenclature of parts and components which are actually serving similar purposes. Therefore, it would be impossible to prepare a common procedure that could be used effectively with all weapons.

- c. Check and record the remaining boresight adjustment limits of movement as outlined in paragraph 6.2.1.2 above.

6.2.2.2 Coaxial Machine Gun

Boresight the coaxial machine gun immediately after boresighting the main gun, using the same target as that used for the main gun, by performing the following:

- a. Remove all superelevation from the fire control system, when appropriate, and lay the aiming cross of the primary sight for the main gun on the aiming point by use of the weapon system controls. Then, if a separate sight is available for the coaxial machine gun, move it to the aiming point by the use of its boresight knobs.
- b. Remove parts as required to permit looking through the gun barrel.
- c. Looking through the barrel, move the axis of the barrel to the same aiming point by using the adjusting mechanisms on the machine gun mount.
- d. Check and record the remaining boresight adjustment limits of movement as outlined in paragraph 6.2.1.2 above.
- e. Recheck to ensure that the sights and the machine gun are on the same aiming point and then reassemble the gun.

6.2.2.3 Cupola Mounted Machine Gun

Boresight the cupola mounted machine gun as follows:

- a. Position a target with a clearly defined right angle at the range indicated in the technical manual or other appropriate document for the weapon.
- b. Remove parts as required to permit looking through the gun barrel.
- c. Sighting through the gun barrel, use the weapon system controls to align the axis of the barrel on the selected aiming point.
- d. Without moving the machine gun, refer the boresight point of the sight reticle to the same aiming point by use of the adjustment knobs.
- e. Check and record boresight adjustment limits of movement as outlined in paragraph 6.2.1.2 above.
- f. Recheck to ensure that the sight and the gun are on the same aiming point and replace the gun parts.

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6.2.2.4 Combat Vehicle Mounted Searchlights

Boresight the searchlight after the main gun has been boresighted, to establish a definite relationship between the axis of the main gun tube, the direct fire sights, and the beam of the searchlight, and proceed generally as follows:

NOTE: The method will vary depending upon the type light, and installation being used.

- a. Place the boresight panel or target(s) as described in the pertinent technical manual or other appropriate document for the particular system being used at the specified distance from the vehicle.
- b. Prepare the weapon/fire control system as specified in the pertinent technical manual or other appropriate document for the particular installation being tested.
- c. Align the gun or sight, as prescribed, on the boresight panel or targets as specified for the system.
- d. Align the searchlight on the boresight panel or target, as prescribed, by using the means provided for moving the light or its mount in elevation and deflection.
- e. Check and record the remaining boresight adjustment limits of movement as outlined in paragraph 6.2.1.2, above.

6.2.3 Zeroing

Zero the main gun and coaxial and cupola mounted machine guns, in accordance with the following procedures:

- a. All zeroing rounds shall be of the same type and lot number.
- b. Since zeroing will follow immediately after boresighting, instructions for positioning the weapon system are the same as in paragraph 6.2.2.
- c. Record the following for each subparagraph below:
 - 1) Identity of each technical manual/document used.
 - 2) Nomenclature of items tested (gun and sight).
 - 3) Type and size of target used, as specified.
 - 4) Range, in yards.
 - 5) Type and lot number of ammunition used for zeroing.
 - 6) Number of rounds per group/burst.
 - 7) Total groups/bursts fired.
 - 8) Date fired.
 - 9) Ambient temperature, in degrees F.
 - 10) Weather conditions, including wind speed and direction.
 - 11) Remaining adjustment limits of movement to the left, right, above, and below the specified setting, as described in paragraph 6.2.1.2.
 - 12) Difficulties, if any, encountered in zeroing.

6.2.3.1 Main Gun

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Upon completion of boresighting, zero the main gun as prescribed in the appropriate technical manual or other pertinent document; proceed generally as follows, especially for single shot firing:

- a. Position a vertical panel target (such as shown in Appendix B) with a clearly defined aiming cross at the range specified in the technical manual or other appropriate document.
- b. Fire a warm-up round. This is only for warming the tube and is not to be counted as a zeroing round. Record the type of round used.
- c. Index in the fire control system the range and type of ammunition, if applicable, to be fired.
- d. Using the manual controls make a precise lay on the aiming cross.

NOTE: When zeroing, all final lays of the main gun should be made in the same direction (usually from low to high and from right to left) against pressure. For example, if after firing around the sight is only slightly off the original lay, the gun should be moved a sufficient distance to ensure all slack (backlash) in the system will be completely removed during re-lay.

- e. Fire one round, check, and proceed as follows:

- 1) If the projectile strikes the outer portion of the target, adjust as required to ensure that subsequent rounds do not miss the target.
- 2) If the projectile strikes well within the target, continue to fire, re-laying in the manner described in the note under step d above, after each round until a group of five usable rounds is obtained.

NOTE: A round should be considered unusable when its deviation exceeds two times the standard deviation of the 5-round group of which it is a part. This is usually determined by a visual inspection, but in case of doubt, an additional round should be fired immediately.

- 3) Measure the vertical and horizontal distance of each impact from the aiming point and use these data to determine the center of impact (CI) for the 5-round group.

NOTE: The CI is the midpoint of the group or the average distance of all rounds from the point of aim.

- f. Make a precise re-lay on the target aiming cross. Without disturbing the lay of the gun, move the sight to the center of the shot group by use of the boresight knobs. Re-lay on the original aiming point and fire another group of five usable rounds, re-laying after each round as before. Measure the distance of each impact from the aiming point and determine the CI, as described in step e above.

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NOTE: This CI should be within 24 inches of the aiming point, preferably closer.

g. If the results of step f are not within specified limits, repeat the procedures of step f.

NOTE: The CI should be as close to the center of the target (aiming point) as possible to increase the probability of all rounds hitting the standard size targets that will be used for dispersion firing. One reason for firing at least five rounds in the zeroing group is to permit using it as a part of dispersion firing. If hit probability is computed from the dispersion firing groups, the distance of the zeroing CI from the aiming point must be taken into account.

h. Re-lay as if to fire and then align other main armament sights, if any, on the same point. Record all sight settings.

NOTE: These are the zero settings for this gun/sight/ammunition combination.

i. Check and record the remaining boresight adjustment limits of movement as outlined in paragraph 6.2.1.2 above.

6.2.3.2 Coaxial Machine Gun

Upon completion of zeroing the main gun, proceed to zero the coaxial machine gun as follows:

- a. Position a vertical panel target at the range specified in the technical manual or other appropriate document.
- b. Index the range in the fire control system.
- c. Index the ammunition in the fire control system. If machine gun ammunition cannot be indexed, index the type of main armament ammunition specified in the technical manual or other appropriate document.
- d. Using manual controls, lay the aiming cross of the gunner's periscope precisely on the target. If a machine gun sight (infinity) is available, refer this reticle to the same point using its boresight knobs.
- e. Fire a burst of 20-25 rounds observing the fire with the main gun primary direct fire sight. If the beaten zone of the burst fails to hit the target, adjust the coaxial machine gun mount to move the beaten zone to the target. Repeat this procedure until the beaten zone hits the target.
- f. Check and record the remaining boresight adjustment limits of movement as outlined in paragraph 6.2.1.2 above.

6.2.3.3 Cupola Mounted Machine Gun

Upon completion of boresighting, zero this weapon as follows:

- a. Position a vertical panel target with a clearly defined aiming

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point at the range specified in the technical manual or other appropriate document.

- b. Make a precise lay on the aiming point.
- c. Fire a burst of 10-20 rounds and observe and beaten zone.
- d. Without disturbing the lay of the gun, move the point of the reticle to the center of the beaten zone.
- e. Fire another 10-20 round burst to verify the zero. The weapon is zeroed when the center of the beaten zone is within 24 inches of the aiming point.
- f. Check and record the remaining boresight adjustment limits of movement as outlined in paragraph 6.2.1.2 above.

6.2.4 Boresight Retention

6.2.4.1 Preparation

- a. Position a suitable gridded target in a readily accessible and convenient place, such as a motor park, a boresight target may be used in lieu of the gridded target, on the firing range and record the type of target used.

NOTE: Paragraph 6.2.1.1 and Appendix A describe requirements for a gridded target. The boresight target is described in paragraph 6.2.3 and Appendix B.

- b. Clearly mark the required position for the vehicle so that it will be positioned in exactly the same place for all subsequent boresight retention checks. Record the range.
- c. Position the vehicle at the chosen spot and prepare main gun as for boresighting, as outlined in paragraph 6.2.2.1 above.
- d. Align the axis of the gun tube on the center of the gridded target using manual elevation and traverse controls and making the final lay from the same direction as for zeroing, as noted in paragraph 6.2.3.1d above. Record the direction from which vertical and horizontal lays were made.
- e. Determine the point where each sight is aligned on the target, and mark these points if they are not the same as for the gun tube. Record the identity and setting of each sight aligned.
- f. Determine the backlash in the elevating and traversing systems by re-laying the gun tube from opposite directions from those in step d above. Measure and record the deviation for each of the sights - this is the backlash.
- g. Record the date, hour of day, and ambient temperature.

6.2.4.2 Retention Checks

- a. Before and after each day of firing and at least after each 100 miles of operation (preferably each day) repeat the procedures of paragraph 6.2.4.1 above, and record all pertinent data.

b. Determine and record the following for each retention check:

- 1) Variance in alignment of each sight, and in backlash of each elevating and traversing system, from original data

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- established in paragraph 6.2.4.1.
2) Total test miles and/or rounds fired since previous retention check.

6.3 TEST DATA

6.3.1 Preparation for Test

6.3.1.1 Personnel

Record the name, rank or grade, MOS and experience in MOS for each of the test personnel.

6.3.1.2 Pretest Inspection

Record the following:

- a. Data collected as described in applicable sections of MTP 3-3-500.
- b. Nomenclature and serial number of weapon and the vehicle in which it is installed.
- c. All adjustments and/or repairs made to the weapon system.

6.3.2 Test Conduct

6.3.2.1 Adjustment Limits

Record the following for each sight/mount:

- a. Nomenclature of item tested.
- b. Maximum limits of movement provided, in mils, measured from the center, in the following directions:

- 1) Horizontally to the left
- 2) Horizontally to the right
- 3) Vertically, above
- 4) Vertically, below

- c. Remaining limits of movement, in mils, measured from the bore-sight setting, in the same directions as step b above.

6.3.2.2 Boresighting

Record the following for each item boresighted:

- a. Nomenclature of item tested.
- b. Identity of each technical manual or other document used.
- c. Range at which each item was boresighted.
- d. Type of tools, equipment, and targets used.
- e. Any difficulties encountered during boresighting.
- f. Remaining amount of boresight adjustment movement, as described in

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paragraph 6.2.1.2 above.

6.3.2.3 Zeroing

Record the following:

a. For each subtest (main gun and machine guns):

- 1) Identity of each technical manual/document used.
- 2) Nomenclature of items tested (gun and sight).
- 3) Type and size of target used, as specified.
- 4) Range, in yards.
- 5) Type and lot number of ammunition used for zeroing.
- 6) Number of rounds per group/burst.
- 7) Total groups/bursts fired.
- 8) Data fired.
- 9) Ambient temperature, in degrees F.
- 10) Weather conditions, including wind speed and direction.
- 11) Remaining adjustment limits of movement to the left, right, above, and below the specified setting, as described in paragraph 6.2.1.2.
- 12) Difficulties, if any, encountered in zeroing.

b. For each main gun/sight/ammunition combination:

- 1) Data collected as described in step a above.
- 2) Type of controls used (manual or power).
- 3) Directions from which vertical and horizontal lays were made.
- 4) Type warming round used, if any.
- 5) Unusable rounds fired.
- 6) Vertical, and horizontal distances, in inches, from aiming point:
 - a) For the strike of each round
 - b) For the center of impact of each group
- 7) Identity and setting of each sight

6.3.2.4 Boresight Retention

a. Record the following for all checks:

- 1) Purpose of check (preparation, retention)
- 2) Description of each method used, including:
 - a) Type of target.
 - b) Range, in yards.
 - c) Direction(s) from which vertical and horizontal rays of gun tube were made.
 - d) Identity, and setting of each sight aligned.

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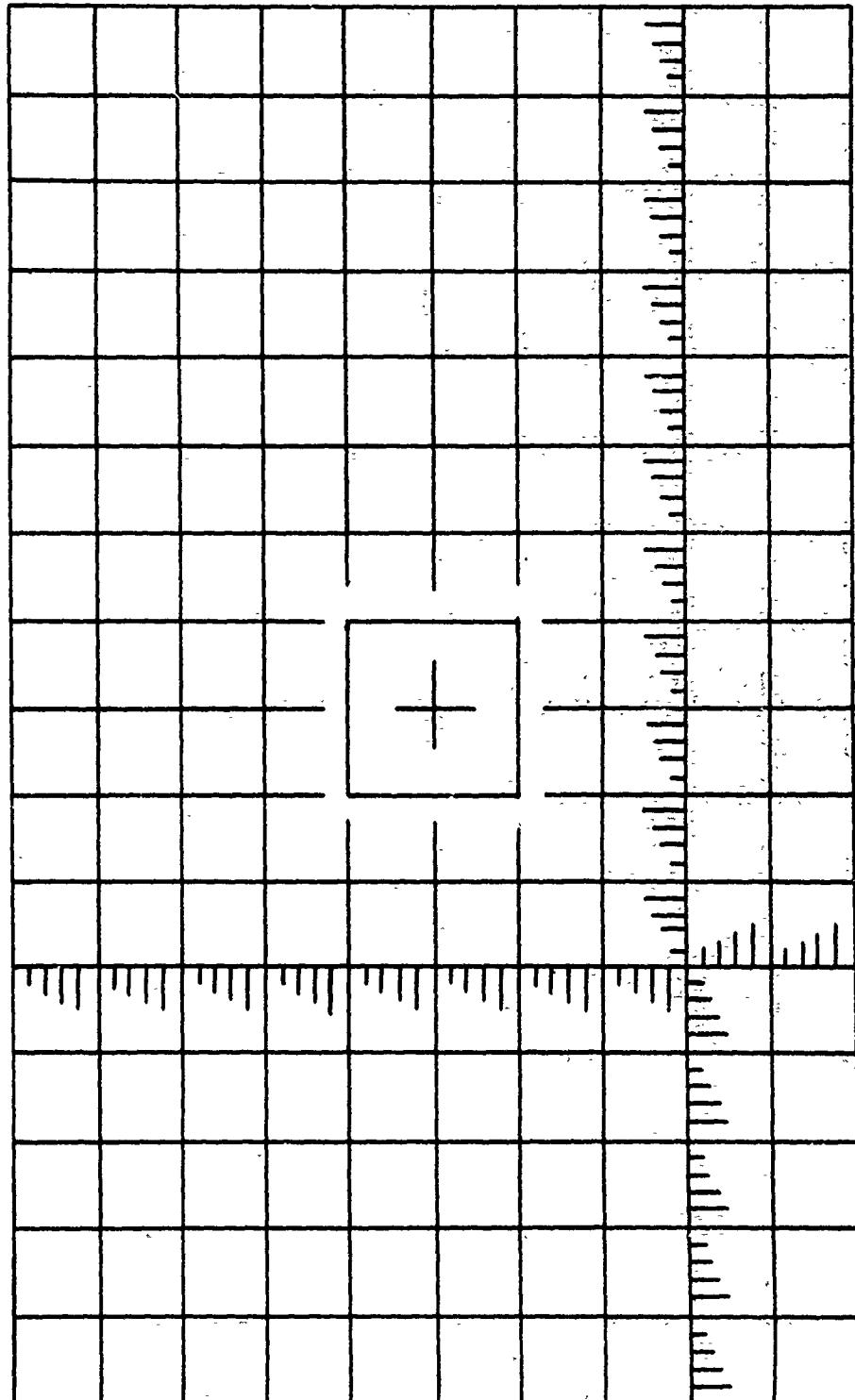
- e) Deviation from original setting of each sight, if any, as noted during each backlash check.
 - 3) Date, and hour of test
 - 4) Ambient temperature, in degrees F
- b. Record the following for retention checks:
- 1) Amount of vertical, and horizontal deviation from each original sight setting for the following:
 - a) Prescribed directions for making lays
 - b) Opposite directions (backlash)
 - 2) Total test miles, and/or rounds fired since previous retention check.

6.4 DATA REDUCTION AND PRESENTATION

Consolidate test data and present graphically, where possible, to show the relationship between boresight loss, rounds fired, miles traveled, or ambient temperatures. When boresight losses or system backlash exceeds that specified by applicable documents and inspection reveals that the cause is other than inadvertent looseness or broken parts, the responsible agency should be notified.

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APPENDIX A
SAMPLE GRIDDED TARGET



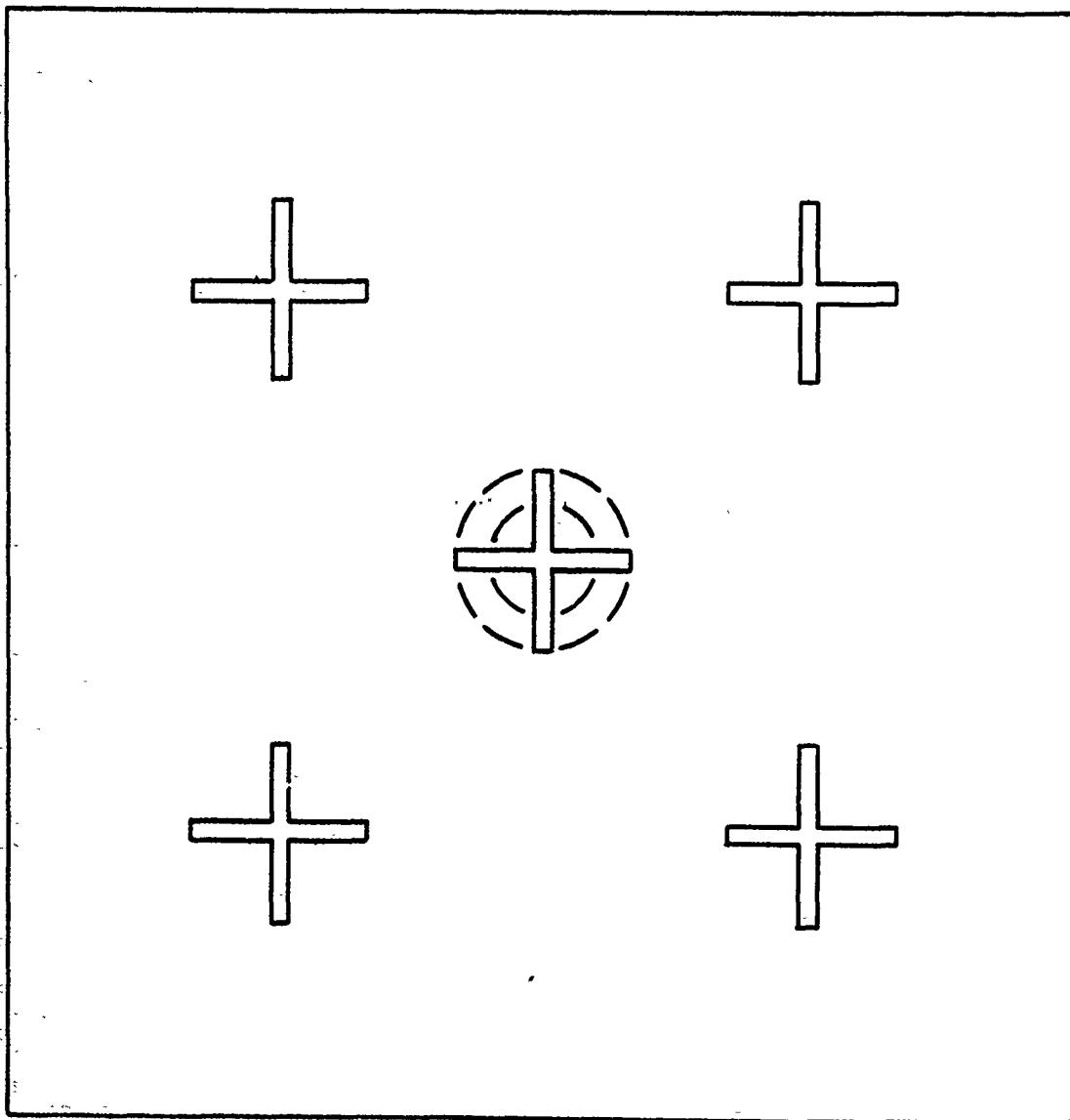
For use as shown in paragraph
6.2.1.1 of basic MTP 3-3-503

Grid Pattern: 0.50-mil squares
Scale: 0.10-mil graduations

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APPENDIX B

SAMPLE BORESIGHT AND ZERO TARGET



Overall dimensions, 6.1m x 6.1m. Center cross and circle pattern is used for zeroing. All crosses have 1 meter members. Outlying patterns are used for confirming zero or round-to-round dispersion.

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11 SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Headquarters

U.S Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland 21005

13 ABSTRACT

This Army Service Test Procedure describes test methods and techniques for Boresighting and Zeroing of Combat Vehicle Mounted Weapons, checking Boresight Retention, and for evaluating the weapon's suitability for service use by the U. S. Army. The evaluation is related to criteria expressed in applicable Qualitative Materiel Requirements (QMR), Small Development Requirements (SDR), Technical Characteristics (TC), or other appropriate design requirements and specifications.

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